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Japan Kokai [Unexamined] Patent 7-176794/1995

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Applicant: 000226057

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Inventor: Y. Shimizu

[Title of Invention]

Planar Light Source

[Abstract]

[Objective]

To realize a planar light source wherein white color is possible by using blue light emitting diodes and to provide a planar light source wherein white luminescence can be observed.

[Constitution]

At the end face of a transparent light-transmitting plate, a light emitting diode is connected optically, and at either one of the main surfaces of the said light transmitting plate, there is a fluorescence scattering layer which is coated with a mixture of a fluorescent substance which emits fluorescent light when excited by the luminescence of the said blue light emitting diode and a white powder which scatters the fluorescent light. The luminescence of the said blue light emitting diode undergoes a change of wavelength at the said fluorescence scattering layer.

[Insert Figure 1]

[Claims of the Patent]

[Claim 1]

Planar light source which is characterized as follows: At at least one site on the end face of a transparent light-transmitting plate, a blue light emitting diode is connected optically, and at either one of the main surfaces of the said light-transmitting plate, there is a fluorescence scattering layer which is coated with a mixture of a fluorescent substance which emits fluorescent light when excited by the luminescence of the said blue light emitting diode and a white powder which scatters the fluorescent light. The luminescence of the said blue light emitting diode undergoes a change of wavelength at the said fluorescence

scattering layer and this is observed from the side of the main surface of the light transmitting plate at the opposite side of the said fluorescence scattering layer.

[Claim 2]

The planar light source described in Claim 1, characterized in that the said blue light emitting diode has a main light emission wavelength which is shorter than 500 nm and that its light emitting output is over 500  $\mu$ W.

[Detailed Description of the Invention]

[0001]

[Field of Application in Industry]

This invention is related to a planar light source that is used as a backlight of displays and back-lighted operating switches. In particular, it is related to a planar light source that can be used suitably as the backlight of a liquid crystal display.

[0002]

[Existing Technology]

Generally, as a planar light source for use as the backlight of a liquid crystal display which is used in notebook type personal computers and Warpro [phonetic transliteration], for example, EL and the cold cathode tube are used. EL is a planar light source by itself and the cold cathode tube is made to be a planar light source by using a diffusion plate; currently, the emitting colors of the these backlights are mostly white.

[0003]

On the other hand, the light emitting diode (hereinafter, this is written as LED) is also used in part as a light source for the backlight. However, in the case of obtaining white luminescence by using the LED, in the past, the luminescence output of blue LEDs was only about several tens of  $\mu$ W, and so in order to realize white luminescence using a red LED and a green LED, it was difficult to match the characteristics of the luminescence LED of each of these colors and thus there was the shortcoming of large variations in color. Also, even when LEDs of 3 primary colors are gathered and

arranged at the geometrically same positions on the same plane, these LEDs are visually recognized [to be] at close adjacent positions as far as the back-light is concerned, and therefore, it was impossible to make a uniform white light source. Consequently, at present, as for the planar light source for a white liquid crystal backlight, the cold cathode tube is used for the large type and the EL is used for the small-medium type, and a backlight of white luminescence using LEDs is almost unknown.  
[0004]

Also, as for the white luminescence or monochromatic light source, there were attempts by some to surround the periphery of the blue LED chip with a resin containing a fluorescent substance; but, since the periphery of the chip is exposed to light rays which have a stronger radiation intensity than sunlight, degradation of the fluorescent substance became a problem; this is particularly true with organic fluorescent substances. Further, with organic dyestuff of the ionic type, electrophoresis is induced near the chip by the dc electrical field and the color tone can change. Also, the existing blue LEDs did not have sufficient output for changing the color by a fluorescent substance, and even if the color change was done, it was not something that could be used practically.

[0005]

[The Problem Which the Invention Intends to Solve]

This invention was accomplished to solve this shortcoming and its objective is to realize, by using LEDs, a planar light source wherein white light can be emitted for use mainly as a backlight and to provide a planar light source wherein uniform white luminescence can be observed. Further, the objective is to provide a planar light source which can emit any color other than white and utilize the excellent reliability characteristics of LEDs and use this in various types of operating switches.

[0006]

[The Means for Solving the Problem]

The planar light source of this invention is characterized as follows: At at least one site on the end face of a transparent

light-transmitting plate, a blue light emitting diode is connected optically, and at either one of the main surfaces of the said light-transmitting plate, there is a fluorescence scattering layer (hereinafter, the main surface of the fluorescence scattering layer side is called the "second main surface") which is coated with a mixture of a fluorescent substance that emits fluorescent light when excited by the luminescence of the said blue light emitting diode and a white powder which scatters the fluorescent light. A part of the luminescence of the said blue light emitting diode undergoes a change of wavelength at the said fluorescence scattering layer and this is observed from the side of the main surface (hereinafter, the main surface of the luminescence observation side is called the "first main surface") of the light transmitting plate at the opposite side of the said fluorescence scattering layer.

[0007]

Figure 1 is a top view of the light-transmitting plate 2 of the planar light source of this invention as seen from the side of the fluorescence scattering layer 3. The light transmitting plate 2 is made of a transparent material such as acrylic or glass. At the end face of this light transmitting plate 2, a blue LED 1 is buried, and by this, the light transmitting plate 2 and the blue LED 1 are connected optically. Now, in this invention, that the blue LED 1 and the end face of the light transmitting plate 2 are optically connected means, in brief, that the light of the blue LED is led in from the end face of the light transmitting plate 2. For example, as indicated in this figure, this can be realized by burying the blue LED 1, of course, and by bonding the blue LED or by using an optical fiber to lead the luminescence of the blue LED to the end face of the light transmitting plate 2.

[0008]

Next, the fluorescence scattering layer 3 is made by coating an ink in which the fluorescent substance and the white pigment are mixed so that the desired color can be observed. The luminescence of blue LED 1 is wavelength-converted by the fluorescent substance, and at the same time, the fluorescence is scattered inside the

light-transmitting plate 2 by the white pigment. Particularly in Figure 1, the said fluorescence scattering layer 3 is made into the dot shape, and to keep the surface brightness of the side of the first main surface constant, the pattern is set such that, as the LED 1 is approached, the area of the fluorescence scattering layer 3 per unit area at the second main surface side is reduced; further, the area at the end section of the second main surface which is separated farthest from the LED 1 is made somewhat smaller than the maximum area. Here, the black rectangles in Figure 1 express the pattern of the fluorescence scattering layer 3. In Figure 1, the construction is one in which two blue LEDs are positioned at one end face; but it goes without saying that, if the light transmitting plate is a square shape, LEDs can be connected at all end faces at four sides. Also, the number of LEDs is not limited either. Further, depending on the arrangement of the LEDs, in order to have the luminescence observed from the side of the first main surface be uniform in a plane, one can suitably change the coating shape of the fluorescence scattering layer and the coating state.

[0009]

[Action]

Figure 2 is a schematic cross section diagram in the case of mounting the planar light source of this invention as a backlight of the liquid crystal panel, for example. In this, at the side of the second main surface of the planar light source shown in Figure 1, there is installed a reflection plate which is made by laminating, for example, a scatter reflection layer 6 consisting of barium titanate, titanium oxide, aluminum oxide and a base 7 consisting of Al, and at the side of the first main surface, there is installed a light diffusing plate 5 whose surface is made uneven. This construction has no particular difference from the backlight in which a cold cathode tube is used as the light source.

[0010]

First, as indicated by the arrow sign of Figure 2, the light which comes out from the blue LED 1 is radiated near the chip to

the outside, excluding a part of the light transmitting plate, but most of the light reaches the end face of the light transmitting plate while repeating total reflection in the light transmitting plate 2. The light which reaches the end face is reflected at the reflection membrane 4 which is formed at all of the end faces and repeats total reflection. At this time, a part of the light is scattered by the fluorescence scattering layer which is installed at the second main surface side of the light transmitting plate 2; also, a part of the light is absorbed by the fluorescent substance, and at the same time, is wavelength-converted and is radiated. Thus, as for the color of luminescence observed from the first main surface side of the light transmitting plate 2, the light which is synthesized from these lights can be observed. For example, with a planar light source in which the fluorescence scattering layer 3 consisting of orange colored fluorescent pigment and white pigment, the color of luminescence from the blue LED can be observed as white by the action which was described previously. The color tone can be adjusted optionally by the type of fluorescent substance and the mixing ratio of the white pigment. Particularly in this invention, as to the emission wavelength of one of the blue LEDs, the main emission peak needs to be shorter than 500 nm and its emission output needs to be more than 200  $\mu$ W, more preferably more than 300  $\mu$ W. The reason for this is that, if the emission wavelength is longer than 500 nm, it is difficult to realize all colors, and also, if the emission output is less than 200  $\mu$ W, it tends to be difficult to obtain a light source of planar emission with sufficient and uniform brightness even if the number of blue LEDs connected optically to the end face of the light transmitting plate is increased.

[0011]

[Examples of Application]

[Example of Application 1]

At one side face of the acrylic plate of about 2 mm thickness, the fluorescence scattering layer 3 was formed by screen printing to a pattern of dot form shown in Figure 1. The fluorescence scattering layer 3 was formed by printing with ink which was

prepared as follows: The red fluorescent pigment FA-001 made by Shinroi-hi Kagaku and the green fluorescent pigment FA-005 made by the same firm were mixed in equal amounts to obtain the fluorescent pigment; this and barium titanate as the white powder were mixed by a weight ratio of 1:5 and this mixture was dispersed in an acrylic based binder.

[0012]

Next, the acrylic plate on which the fluorescence scattering layer was formed as described above was cut to the desired pattern. All of the end face (cut face) of the acrylic plate was ground, and on the ground surface, the reflection layer 4 consisting of Al was formed to obtain the light transmitting plate 2 in which the fluorescence scattering layer 3 was formed. [0013]

At two sites on the end face of the said light transmitting plate 2, a hole was installed at each site, and in this hole, one blue LED consisting of a gallium nitride compound semiconductor having an emission wavelength of 480 nm, emission output of 1200  $\mu$ W was buried to obtain the planar light source of this invention. The blue LEDs of this planar light source were lighted simultaneously, and from the side of the emission observation surface of the light transmitting plate 2, approximately uniform planar luminescence of a somewhat yellowish white color was obtained. Further, at the emission observation face side, a light diffusing plate on which a mat processing was applied in advance and a reflection plate in which a barium titanate layer 6 was coated on an Al base 7 were installed at the fluorescence scattering layer side 3 to use as a light source for backlight, and in the result, completely planar, uniform white luminescence was obtained from the light diffusing plate side 5. The brightness was 55 cd/m<sup>2</sup>.

[0014] [Example of Application 2]

The fluorescence scattering layer 3 was formed as follows: As the yellow fluorescent dyestuff, Lumogen F Yellow-083 of the BASF Co. was used, and as the orange color dyestuff, Orange-240 of the same firm was used, and these were mixed in equal amounts; the mixture was dissolved in butyl carbitol acetate to prepare the

fluorescent dyestuff; as the white substance, barium titanate was used; the fluorescent dye stuff and the white substance were mixed by a weight ratio of 1 (dye):200. Other than this, the same procedure as in Example of Application 1 was followed to obtain the planar light source of this invention and approximately uniform planar luminescence was observed. Further, by the same procedure, a light source for backlight was obtained and a perfectly uniform planar luminescence was observed.

[0015]

#### [Effectiveness of the Invention]

As has been explained above, the planar light source of this invention uses blue LEDs, and furthermore, on the surface of one side of the light transmitting plate, it has a fluorescence scattering layer that contains a fluorescent substance that can wavelength-convert [the light emitted] by the blue LED and a white powder, and by this, it has become possible to realize a planar light source by LEDs having excellent reliability. Moreover, the white powder of the fluorescence scattering layer has the action of reflecting and diffusing the light which is wavelength converted by the fluorescent substance and so the amount of use of the fluorescent substance being used can be kept small. Another convenient point is that, as there is no direct contact between the LED chip and the fluorescent substance, there is little degradation of the fluorescent substance, and over a long period, there is no change in the color tone of the planar light source. Further, regarding the color tone, any color tone including white can be provided by varying the types and amounts of mixing of the fluorescent substance and the white powder.

[0016]

On the other hand, as for the side of exciting the fluorescence scattering layer, by making the emission output of the blue LED being used most preferably to be over 200  $\mu$ W, it is possible to realize a bright planar light source of large area by the efficient wavelength-conversion by the fluorescent substance. Thus, the planar light source of this application can be used not only as a light source for the backlight but also in the backlit

operating switch which utilizes a fluorescent substance.

[Brief Description of the Figures]  
[Figure 1]

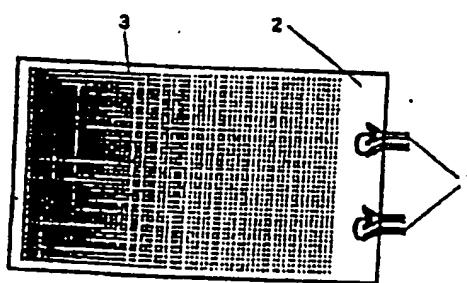
Top view of the light transmitting plate 2 of the planar light source of an example of application of this invention as seen from the side of the fluorescence scattering layer 3.  
[Figure 2]

Schematic cross section diagram in the case of mounting the planar light source of an example of application of this invention as the backlight.

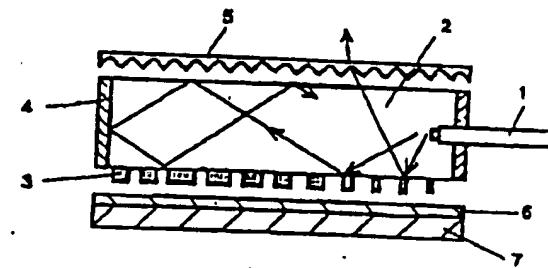
[Description of the Codes]

1 -- Blue LED; 2 -- Light-transmitting plate; 3 -- Fluorescence scattering layer; 4 -- Reflection layer; 5 -- Light diffusing plate; 6 -- Scatter reflection layer; 7 -- Al base

(図1)



(図2)



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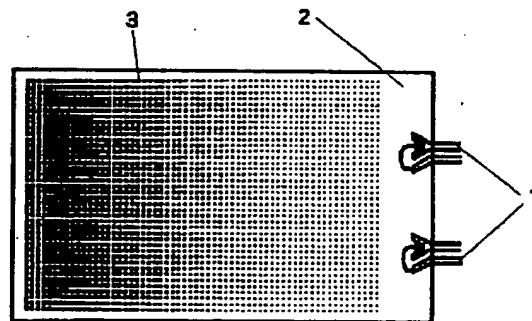
学工業株式会社内

(54) 【発明の名称】 面状光源

(57) 【要約】

【目的】 青色発光ダイオードを用いた白色可能な面状光源を実現し、均一な白色発光を観測できる面状光源を提供する。

【構成】 透明な導光板の端面に発光ダイオードが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層を有し、前記青色発光ダイオードの発光が前記蛍光散乱層で波長変換される。



## 【特許請求の範囲】

【請求項1】 透明な導光板の端面の少なくとも一箇所に青色発光ダイオードが光学的に接続されており、さらに前記導光板の正面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層を有し、前記青色発光ダイオードの発光が前記蛍光散乱層で波長変換され、前記蛍光散乱層と反対側の導光板の正面側から観測されることを特徴とする面状光源。

【請求項2】 前記青色発光ダイオードは、その主発光波長が500nmよりも短く、発光出力が500μW以上であることを特徴とする請求項1に記載の面状光源。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】 本発明はディスプレイのパックライト、照光式操作スイッチ等に使用される面状の光源に係り、特に液晶ディスプレイのパックライトとして好適に用いることができる面状光源に関する。

## 【0002】

【従来の技術】 一般にノート型パソコン、ワープロ等に使用される液晶ディスプレイのパックライト用の面状光源には、例えばEL、冷陰極管が使用されている。ELはそれ自体が面状光源であり、冷陰極管は拡散板を用いて面状光源とされ、現在それらのパックライトの発光色はほとんどが白色とされている。

【0003】 一方発光ダイオード（以下LEDと記す。）もパックライト用光源として一部利用されている。しかしLEDを用いて白色発光を得る場合、従来では青色LEDの発光出力が数十μWほどしかないため、他の赤色LED、緑色LEDを用いて白色発光を実現させるには、それら各色発光LEDの特性を合致させにくく色変化が大きいという欠点がある。また、三原色のLEDを集合させて、同一平面上に幾何学的に同じ位置に配置しても、パックライトとしてはそれらのLEDを接近した位置で視認するため、均一な白色光源にすることは不可能であった。従って現在白色の液晶パックライトの面状光源には、大型では冷陰極管、小型～中型にはELと使い分けられているのが現状で、LEDを用いた白色発光のパックライトはほとんど知られていない。

【0004】 また白色発光、あるいはモノクロの光源として、一部では青色LEDチップの周囲を蛍光物質を含む樹脂で包囲して色変換する試みもあるが、チップ周辺は太陽光よりも強い放射強度の光線にさらされるため、蛍光物質の劣化が問題となり、特に有機蛍光顔料で顕著である。更にイオン性の有機染料はチップ近傍では直流電界により電気泳動を起こし、色調が変化する可能性がある。また従来の青色LEDは蛍光物質で色変換するには十分な出力を有しておらず、たとえ色変換したとしても実用できるものではなかった。

## 【0005】

【発明が解決しようとする課題】 本発明はこのような欠点を解決するために成されたもので、その目的とするところは、LEDを用い、主としてパックライトとして利用できる白色発光可能な面状光源を実現すると共に、均一な白色発光を観測できる面状光源を提供することにあり、さらには白色以外の任意色の発光が可能な面状光源を提供し、信頼性に優れたLEDの特性を利用し、各種操作スイッチ等に利用することにある。

## 【0006】

【課題を解決するための手段】 本発明の面状光源は、透明な導光板の端面の少なくとも一箇所に青色LEDが光学的に接続されており、さらに前記導光板の正面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層（以下、蛍光散乱層側の正面を第二の正面という。）を有し、前記青色発光ダイオードの発光の一部が前記蛍光散乱層で波長変換され、前記蛍光散乱層と反対側の導光板の正面

20 （以下発光観測側の正面を第一の正面という。）側から観測されることを特徴とする。

【0007】 図1は本発明の面状光源の導光板2を蛍光散乱層3側から見た平面図である。導光板2は例えばアクリル、硝子等の透明な材料よりなり、その導光板2の端面に青色LED1が埋設されることにより、導光板2と青色LED1とが光学的に接続されている。なお本発明において、青色LED1と導光板2の端面とが光学的に接続されているとは、簡単に言えば、導光板2の端面から青色LEDの光を導入することをいい、例えばこの30 図に示すように青色LED1を埋設することはもちろんのこと、青色LEDを接着したり、また、光ファイバー等を用いて導光板2の端面に青色LEDの発光を導くことによって実現可能である。

【0008】 次に、蛍光散乱層3は、所望の色が観測できるように、蛍光物質と白色顔料とを調合したインクが塗布されており、青色LED1の発光を蛍光物質で波長変換すると同時に、白色顔料でその蛍光を導光板2内に散乱させている。特に図1では前記蛍光散乱層3をドット状とし、第一の正面側の表面厚さが一定となるよう40 に、LED1に接近するにつれて、第二の正面側の単位面積あたりの蛍光散乱層3の面積を減じるようなパターンとし、さらにはLED1と最も離れた第二の正面の端部の面積はやや最大面積に比して若干小さくしている。

ここで、図1中の■は蛍光散乱層3のパターンを表している。図1では青色LEDを一つの端面に2個配した構造としているが、導光板が四角形であれば四方の端面全てにLEDを接続してもよいことはいうまでもなく、LEDの個数も限定するものではない。さらに、LEDの配置状況により、第一の正面側から観測する発光を面状50 均一とするように蛍光散乱層の塗布形状、塗布状態を適

宜変更することができる。

【0009】

【作用】図2は本発明の面状光源を例えれば液晶パネルのパックライトとして実装した場合の模式断面図である。これは図1に示す面状光源の第二の主面側に、例えばチタン酸バリウム、酸化チタン、酸化アルミニウム等よりなる散乱反射層6と、例えばA1よりなるベース7とが積層された反射板を設置し、第一の主面側に表面が凹凸とされている光拡散板5を設置しており、これらの構成は光源を冷陰極管とするパックライトと特に変わるものではない。

【0010】まず図2の矢印で示すように、青色LED1から出た光は、チップ近傍で一部導光板以外の外部に放射されるが、大部分の光は導光板2の中を全反射を繰り返しながら、導光板の端面に達する。端面に達した光は端面全てに形成された反射膜4に反射されて、全反射を繰り返す。この時、導光板2の第二の主面側に設けられた蛍光散乱層3により一部の光は散乱され、また一部の光は蛍光物質により吸収され同時に波長変換されて放射され、導光板2の第一の主面側から観測する発光色はこれらの光を合成した光が観測できる。例えば橙色の蛍光顔料と白色顔料からなる蛍光散乱層3を設けた面状光源では、先に述べた作用により、青色LEDからの発光色が白色となって観測できる。また色調は蛍光物質の種類と白色顔料の混合比により任意に調整できる。特に本発明では一つの青色LEDの発光波長はその主発光ピークが500nmよりも短く、その発光出力は200μW以上、更に好ましくは300μW以上の出力が必要である。なぜなら発光波長が500nm以上であると全ての色が実現しにくくなり、またその発光出力が200μWよりも少ないと、たとえ導光板の端面に光学的に接続する青色LEDの数を増やしても、充分な明るさの均一な面状発光の光源が得られにくい傾向にあるからである。

【0011】

【実施例】

【実施例1】厚さ約2mmのアクリル板の片面に、図1に示すドット状のパターンで、蛍光散乱層3をスクリーン印刷により形成した。蛍光散乱層3は、赤色蛍光顔料であるシンロイヒ化学製FA-001と緑色蛍光顔料である同社製FA-005とを等量に混合した蛍光顔料と、白色粉末としてチタン酸バリウムとを重量比で1:5の割合で混合し、それをアクリル系パインダー中に分散したものを印刷して形成した。

【0012】次に上記のようにして蛍光散乱層が形成されたアクリル板を、所望のパターンに従って切断し、アクリル板の端面(切断面)を全て研磨した後、研磨面にA1よりなる反射層4を形成することにより、蛍光散乱層3が形成された導光板2を得た。

【0013】前記導光板2の端面に二箇所、穴を設け、その穴に発光波長480nm、発光出力1200μWを

50 1···青色LED

有する窒化ガリウム系化合物半導体よりなる青色LEDをそれぞれ1個づつ埋め込むことにより、本発明の面状光源を得た。この面状光源の青色LEDを同時に点灯させたところ、導光板2の発光観測面側からはやや黄色みを帯びた白色のほぼ均一な面状発光が得られた。さらに、発光観測面側に予めマット加工が施された光拡散板5と、蛍光散乱層3側にA1ベース7上にチタン酸バリウム層6が塗布された反射板を設置して、パックライト用光源としたところ、光拡散板5側から完全に面状均一な白色発光が得られた。輝度は55cd/m<sup>2</sup>であった。

【0014】【実施例2】蛍光散乱層3を、黄色蛍光染料としてBASF社のLumogen F Yellow-083と橙色蛍光染料として同社製Orange-240とをほぼ等量混合し、それらをブチルカルビトールアセテートに溶解した蛍光染料と、白色物質としてチタン酸バリウムとを重量比で1(染料):200の割合で混合したものを用いて形成する他は、実施例1と同様にして本発明の面状光源を得たところ、ほぼ均一な面状発光が観測された。さらに同様にしてパックライト用光源としたところ、完全に均一な面状発光が観測された。

【0015】

【発明の効果】以上説明したように、本発明の面状光源は、青色LEDを用い、しかも導光板の片方の面に青色LEDにより波長変換できる蛍光物質と白色粉末とを含有した蛍光散乱層を有していることにより、信頼性に優れたLEDによる面状光源を実現することが可能となった。しかも蛍光散乱層の白色粉末は、蛍光物質により波長変換された光を反射、拡散させる作用があるため、使用する蛍光物質の使用量が少なくて済む。更に好都合なことには、LEDチップと蛍光物質とが直接接することができないので、蛍光物質の劣化が少なく、長期間に渡って面状光源の色調変化を起こすことがない。さらに、色調に関しては、蛍光物質、白色粉末の種類、混合量等を変更することにより、白色を含め任意の色調を提供することができる。

【0016】一方蛍光散乱層を励起する側として、最も好ましくは使用する青色LEDの発光出力が200μW以上のものとすることにより、蛍光物質により効率的に波長変換して大きな面積の明るい面状光源を実現することができる。このように、本願の面状光源は、パックライト用光源とだけでなく、蛍光物質を利用した照光式操作スイッチ等に利用することもできる。

【図面の簡単な説明】

【図1】 本発明の一実施例の面状光源の導光板2を蛍光散乱層3側から見た平面図。

【図2】 本発明の一実施例の面状光源をパックライトとして実装した場合の模式断面図。

【符号の説明】

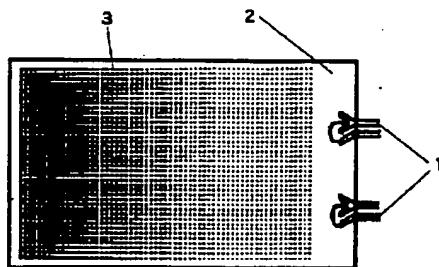
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2 ·····導光板  
3 ·····蛍光散乱層  
4 ·····反射層

6

5 ·····光拡散板  
6 ·····散乱反射層  
7 ·····A1ベース

【図1】



【図2】

